What is claimed is:

1.   A precoder for generating a mapped constellation signal from an input signal,

2   comprising:

3   a feedback filter that generates a feedback signal as a function of the mapped

4   constellation signal, and

5   a discrete modulo adder that generates the mapped constellation signal from the input

6   signal and the feedback signal, the discrete modulo adder utilizing an index to the constellation

7   of levels chosen for the precoder, such that the amplitude of the mapped constellation signal is

8   limited.

1   2.   The precoder according to claim 1, wherein the discrete modulo adder comprises:

2   an adder that adds together the feedback signal and the input signal to generate a

3   partial result, and

4   a mapper that generates the mapped constellation signal by mapping a partial result

5   outside a basic constellation of levels onto the basic constellation of levels as a function of the

6   index to the constellation of levels for the precoder.

1   3.   The precoder according to claim 1, wherein the feedback filter includes a delay

2   element and a weighting element such that the feedback filter multiplies a delayed version of

3   the mapped constellation signal by the weighting element to generate the feedback signal.

1   4.   The precoder according to claim 1, wherein the feedback filter is based upon a

2   model of the impulse response of a communication channel.

1   5.   The precoder according to claim 2, wherein the mapper further comprises:

2 a table identifying a basic constellation of levels and a mapping from levels outside the

3 basic constellation to levels inside the basic constellation.

1 6. The precoder according to claim 5, wherein each of the levels outside the basic

2 constellation in the table are mapped onto only one level inside the basic constellation in the

3 table.

1 7. The precoder according to claim 5, further comprising:

2 a table having a constellation index basic_const, where basic_const goes from 1 to k,

3 associated with each of a plurality of levels inside the basic constellation, and having a

4 constellation index positive_const, where positive_const goes from k+1 to m, associated with

5 a plurality of levels outside the basic constellation.

1 8. The precoder according to claim 7, wherein each of the plurality of levels outside

2 the basic constellation index are mapped onto a level inside the basic constellation according

3 to the equation:

4 index positive_const $\rightarrow$ positive_const – (2*k) ; while positive_const > m-k; and

5 index positive_const $\rightarrow$ positive_const – (2*k) –1 ; while positive_const <= m-k;

6 wherein $\rightarrow$ identifies the mapping function.

1 9. The precoder according to claim 5, further comprising:

2 a table having a constellation index basic_const, where basic_const goes from -1 to -k,

3 associated with each of a plurality of levels inside the basic constellation, and having a

4 constellation index negative_const, where negative_const goes from –k-1 to -m, associated

5 with a plurality of levels outside the basic constellation.

21

1   10. 'The precoder according to claim 9, wherein each of the plurality of levels outside

2   the basic constellation index are mapped onto a level inside the basic constellation according

3   to the equation:

4   index negative_const $\rightarrow$ negative_const + (2*k) ; while negative_const < -(m-k); and

5   index negative_const $\rightarrow$ negative_const + (2*k) +1 ; while negative_const >= -(m-k);

6   wherein $\rightarrow$ identifies the mapping function.

1   11. The precoder according to claim 7, wherein the mapper further comprises a

2   comparator for comparing the partial result with the levels in the table.

1   12. The precoder according to claim 11, wherein the comparator identifies the level

2   closest to the partial result.

1   13. The precoder according to claim 12, wherein the mapper further includes an output

2   block that generates a mapped constellation signal equal to a level inside the basic

3   constellation, if the identified level in the table closest to the partial result is inside the basic

4   constellation.

1   14. The precoder according to claim 12, wherein the output block includes a summer

2   for adding the partial result and a mapping distance signal, wherein the mapping distance

3   signal equals the distance between the index basic_const, associated with the basic

4   constellation level of the input signal, and the index positive_const, associated with a level

5   outside the basic constellation.

1   15. The precoder according to claim 1, further comprising a digital to analog converter

2   that generates an analog output signal based upon the mapped constellation signal.

1   16. The precoder according to claim 15, further comprising a transformer for operably

2   coupling the digital to analog converter to an analog subscriber loop.

1   17. The precoder according to claim 15, wherein successive levels in the basic

2   constellation are separated by a distance D1, and wherein a plurality of successive levels

3   outside the basic constellation are separated by a distance D2 such that D1 differs from D2.

1   18. A precoder for an analog modem, the precoder comprising:

2   a discrete modulo adder that generates a mapped constellation signal as a function of a

3   feedback signal and an input signal to the precoder, the discrete modulo adder including:

4   an adder that adds together the feedback signal and the input signal to generate

5   a partial result,

6   a table identifying a basic constellation of levels and levels outside the basic

7   constellation, wherein the levels outside the basic constellation are mapped onto levels inside

8   the basic constellation as a function of an index associated with each level in the table,

9   a comparator for comparing the partial result with the levels in the table,

10   an output block that generates a mapped constellation signal equal to a level

11   inside the basic constellation by mapping a partial result outside the basic constellation of

12   levels onto a level inside the basic constellation of levels, and

13   a feedback filter that generates the feedback signal as a function of the mapped

14   constellation signal output by the discrete modulo adder.

1   19. The precoder according to claim 18, wherein each of the levels outside the basic

2   constellation in the table are mapped onto only one level inside the basic constellation in the

3   table.

23

1   20. The precoder according to claim 18, further comprising

2   a table having a constellation index basic_const, where basic_const goes from 1 to k,

3   associated with each of a plurality of levels inside the basic constellation, and having a

4   constellation index positive_const, where positive_const goes from k+1 to m, associated with

5   a plurality of levels outside the basic constellation.

1   21. The precoder according to claim 20, wherein each of the plurality of levels outside

2   the basic constellation index are mapped onto a level inside the basic constellation according

3   to the equation:

4   index positive_const → positive_const – (2*k) ; while positive_const > m-k; and

5   index positive_const → positive_const – (2*k) –1 ; while positive_const <= m-k;

6   wherein → identifies the mapping function.

1   22. The precoder according to claim 18, further comprising:

2   a table having a constellation index basic_const, where basic_const goes from -1 to -k,

3   associated with each of a plurality of levels inside the basic constellation, and having a

4   constellation index negative_const, where negative_const goes from –k-1 to -m, associated

5   with a plurality of levels outside the basic constellation.

1   23. The precoder according to claim 22, wherein each of the plurality of levels outside

2   the basic constellation index are mapped onto a level inside the basic constellation according

3   to the equation:

4   index negative_const → negative_const + (2*k) ; while negative_const < -(m-k); and

5   index negative_const → negative_const + (2*k) +1 ; while negative_const >= -(m-k);

6   wherein → identifies the mapping function.

24

1   24. The precoder according to claim 20, wherein the output block includes a summer

2   for adding the partial result and a mapping distance signal, wherein the mapping distance

3   signal equals the distance between the index basic_const, associated with the basic

4   constellation level of the input signal, and the index positive_const, associated with a level

5   outside the basic constellation.

1   25. A method of precoding an input signal to generate a mapped constellation signal,

2   comprising:

3   generating a feedback signal from the mapped constellation signal, and

4   performing a discrete modulo operation on the feedback signal and the input signal

5   based upon an index to the constellation of levels chosen for the precoder, such that the

6   amplitude of the mapped constellation signal is limited.

1   26. The method of precoding according to claim 25, wherein the step of performing a

2   discrete modulo operation includes:

3   adding together the input signal and the feedback signal to generate a partial

4   result,

5   determining whether the generated partial result is contained within a basic

6   constellation of levels, and

7   generating the mapped constellation signal by mapping a partial result outside the basic

8   constellation of levels onto a level inside the basic constellation of levels as a function of the

9   index to the constellation of levels for the precoder.

1   27. The method according to claim 25, wherein the step of generating the feedback

2   signal further includes multiplying a delayed version of the mapped constellation signal by a

3   weighting element to generate the feedback signal.

1   28. The method according to claim 26, wherein the determining step further includes

2   comparing the generated partial result with a table identifying a basic constellation of levels

3   and a plurality of levels outside the basic.

1   29. The method according to claim 28, further including generating a mapped

2   constellation signal equal to the partial result if the partial result is inside the basic

3   constellation of levels.

1   30. The method according to claim 28, further including the step of determining

2   whether the partial result is less than the minimum level of the basic constellation or whether

3   the partial result is greater than the maximum level of the basic constellation.

1   31. The method according to claim 30, further including the step of determining a

2   mapping distance p_j when the partial result is less than the minimum level of the basic

3   constellation, the mapping distance p_j being equal to a distance between an index basic_const,

4   associated with the basic constellation level of the input signal, and an index positive_const,

5   associated with a level outside the basic constellation.

1   32. The method according to claim 31, wherein the index positive_const is an index to

2   a level that maps onto the basic constellation level of the input signal, and wherein index

3   positive_const is an index to a level in a positive constellation of levels that includes those

4   levels greater than the maximum level in the basic constellation.

1   33. The method according to claim 32, further including the step of obtaining the index

2   positive_const from a table.

1   34. The method according to claim 31, further including the step of generating a

2   mapped constellation signal by adding together the partial result and the mapping distance p_j .

1   35. The method according to claim 30, further including the step of determining a

2   mapping distance n_j when the partial result is greater than the maximum level of the basic

3   constellation, the mapping distance n_j being equal to a distance between an index basic_const,

4   associated with the basic constellation level of the input signal, and an index negative_const,

5   associated with a level outside the basic constellation.

1   36. The method according to claim 35, wherein the index negative_const is an index to

2   a level that maps onto the basic constellation level of the input signal, and wherein index

3   negative_const is an index to a level in a negative constellation of levels that includes those

4   levels less than the minimum level in the basic constellation.

1   37. The method according to claim 36, further including the step of obtaining the index

2   negative_const from a table.

1   38. The method according to claim 35, further including the step of generating a

2   mapped constellation signal by adding together the partial result and the mapping distance n_j .

1   39. A computer-readable medium having stored thereon a plurality of instructions, the

2   plurality of instructions including instructions that when executed by a processor cause the

3   processor to implement a method of precoding an input signal to generate a mapped

4   constellation signal, the method comprising:

5   generating a feedback signal from the mapped constellation signal, and

27

6   performing a discrete modulo operation on the feedback signal and the input

7   signal based upon an index to the constellation of levels chosen for the precoder, such that the

8   amplitude of the mapped constellation signal is limited.

1   40. The computer-readable medium of claim 39, wherein the step of performing a

2   discrete modulo operation further includes:

3   adding together the input signal and the feedback signal to generate a partial result,

4   determining whether the generated partial result is contained within a basic

5   constellation of levels, and

6   generating the mapped constellation signal by mapping a partial result outside the basic

7   constellation of levels onto a level inside the basic constellation of levels.

Add this

28